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ABSTRACT

The Jacques Cousteau National Estuarine Research Reserve (JC NERR) program has successfully capitalized on human fascination with the ocean by using the marine environment to develop interest and capability in science. The Institute of Marine & Coastal Sciences, as the managing agency of the JC NERR, makes its faculty, staff resources, and advanced technology available to educators and their students. With the selection of model science programs and the development of collaborative school projects and Internet connections, IMCS strives to make science education more exciting and relevant to current environmental policy issues. In designing and conducting K-12 educational programs, the reserve immerses the whole school in learning; provides sustainable professional development supported by the science community; utilizes a learner-centered, constructivist paradigm; uses the environment as an integrating context across disciplines and subject matter; uses evaluation to revise and improve the program; involves the community; and uses the Internet to enhance the program. With this approach, educators can replace arduous rote memorization exercises commonly associated with the study of science with first-hand experiences within the scientific and cultural resources of New Jersey. Encouraging scientists and educators to work together to spark interesting and meaningful science learning in the classroom helps students become better prepared not only as potential scientists, but also as informed decision makers and citizens. (Contains 15 references.) (TD)

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BEST PRACTICES IN MARINE AND COASTAL SCIENCE EDUCATION: LESSONS LEARNED FROM A NATIONAL ESTUARINE RESEARCH RESERVE

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Abstract – The Jacques Cousteau National Estuarine Research Reserve (JC NERR) program has successfully capitalized on human interest and fascination with the ocean by using the marine environment as an entry point to develop interest and capability in understanding science. This natural interest can be used as a springboard to encourage educators and their students to use the marine environment as a focal point while developing basic skills in reading, writing, math, problem-solving, and critical thinking. The Institute of Marine & Coastal Sciences (IMCS), as the managing agency of the JC NERR has remained committed to making its faculty, staff resources and advanced technology available to educators and their students. With the selection of model science programs and the development of collaborative school projects and Internet connections, IMCS strives to make science education more exciting and relevant to current environmental policy issues. With this approach, educators can short circuit the arduous rote memorization exercises commonly associated with the study of science, and replace it with first-hand experiences found within the scientific and cultural resources of New Jersey. By encouraging scientists and educators to work together to spark interesting and meaningful science learning in the classroom, NJ students become better prepared not only as potential scientists, but as informed decision-makers and citizens as well.

The JC NERR K-12 education program is designed to empower classroom teachers and the school community to become facilitators of scientific learning based in an interdisciplinary context. JC NERR education programs are designed to:

1. Build knowledge and skills by providing classroom teachers with basic ecological knowledge and the skills necessary to foster interesting and meaningful learning grounded in science.
2. Evaluate attitudes through the program's ability to:
   - Foster intellectual interest and self-confidence
   - Develop an understanding of nature and a sense of curiosity
   - Enable individuals to perceive the environment in a more realistic way and with greater awareness and commitment.

Introduction

The Jacques Cousteau National Estuarine Research Reserve (JC NERR) is part of a network of protected areas established to improve the health of the nation's estuaries and coastal habitats by developing and providing information that promotes informed resource management. The Reserve provides research and education opportunities and practical information for a wide variety of audiences, from "kindergarten to senior citizens" including K-12 educators, students, local/state government, families, resource users, tourists, elder hostel, etc. The NERR system is a system of sites that serve as living laboratories where scientists, educators, and coastal managers work together to improve land use management and decision-making/policy-making in the coastal zone.

The JC NERR is composed of public lands held by various state and federal entities. Encompassing just over 110,665 acres of terrestrial, wetland, and aquatic habitats, the Mullica River-Great Bay Estuary is regarded as one of the least disturbed estuaries in the densely populated urban corridor of the Northeastern United States. The Reserve is an excellent site to provide a long-term database for valuable management of coastal resources.

Research and education programs enhance public understanding of how the Mullica River-Great Bay estuary functions and help to preserve the area for future generations of users. The Jacques Cousteau Coastal Education Center, located in Tuckerton, NJ serves as the hub for outreach and education programs associated with the JC NERR. This state-of-the-art facility is managed by the Institute of Marine & Coastal Sciences

(IMCS) at Rutgers University, and is designed to serve primarily adult learners, including K-12 educators and coastal decision-makers (defined as those who during the course of their professional responsibilities make decisions that affect the coastal zone). This paper will focus on our collective years of experience searching for Best Practices in curricula, programs, and leadership in marine and coastal education/interpretation with respect to the Reserve's principal target audiences of K-12 educators and coastal decision-makers.

Parameters for Best Practices in K-12 Marine & Coastal Science Education

For the past six years, the JC NERR program has successfully capitalized on human interest and fascination with the ocean by using the marine environment as an entry point to develop interest and capability in understanding science. This natural interest can be used as a springboard to encourage educators and their students to use the marine environment as a focal point while developing basic skills in reading, writing, math, problem-solving, and critical thinking. IMCS has remained committed to making its faculty, staff resources and advanced technology available to educators and their students. With the selection of model science programs and the development of collaborative school projects and Internet connections, IMCS strives to make science education more exciting and relevant to current environmental policy issues. With this approach, educators can short circuit the arduous rote memorization exercises commonly associated with the study of science, and replace it with first-hand experiences found within the scientific and cultural resources of New Jersey. By encouraging scientists and educators to work together to spark interesting and meaningful science learning in the classroom, NJ students become better prepared not only as potential scientists, but as informed decision-makers and citizens as well.

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Parameters for Best Practices in K-12 Marine Education

The goal of the JC NERR is to design and implement a collection of education programs that instills the skills necessary to analyze and resolve questions and issues while gaining new knowledge. JC NERR education programs are focused on the educator as the principal facilitator of knowledge in the classroom. Since 1994, the JC NERR has offered professional development opportunities for K-12 educators that incorporate best practices in curriculum design, implementation, and assessment.

The JC NERR education program seeks to *bring the ocean into the classroom* in support of basic skills training, problem solving, and critical thinking. The establishment of JC NERR education programs in New Jersey public schools is designed to promote investigative, inquiry-based science education and to improve the overall quality of science education in NJ public schools. The principal focus of the program is to provide NJ educators with an interdisciplinary marine science program that can be easily and effectively implemented into the classroom. Our objective is to create a cadre of educators who can bring information back to their home schools and support the involvement of the whole school in the program.

The JC NERR has developed an integrated set of educational programs that capitalize on the research and technological assets of the Reserve and its host, the Institute of Marine & Coastal Sciences at Rutgers University, as the nucleus for interdisciplinary learning across grade levels. Through associations with the Reserve program and partners such as the Lawrence Hall of Science, the National Marine Educators Association, Stevens Institute of Technology and Virginia Institute of Marine Science, the JC NERR has attempted to develop innovative concepts for teaching science and forge strong partnerships with K-12 educators. These programs and partnerships have facilitated the integration of research into high-quality professional development programs and educational materials. The Reserve has utilized the following criteria and best practices in designing and conducting K-12 educational programs:

Immerse the whole school in learning.

Teachers may work together in the same building for years but may only have sketchy knowledge of

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what is going on in each other's classrooms. Elementary, middle and high schools alike can be nurturing environments, but fundamentally a collection of one-room schoolhouses (Jacobs 1997). With a whole school approach, administrators and classroom educators can coordinate a cohesive plan of study, matching current assessments with all levels of state standards, and generating quality communication among staff and administration that can help renew the curriculum (Jacobs 1997).

JC NERR programs are focused on an entire school building, across grade levels and including all professional faculty and staff. Leadership Teams of teachers within the school community are created to serve as liaisons between the JC NERR and the school. The Leadership Team serves as peer trainers and facilitators of the program within the school building. The JC NERR also tries to establish strong connections with the school administration, who are often responsible for introducing innovations and who must support team teaching initiatives.

Provide sustainable professional development training and resources supported by the science community

Professional development and training efforts must be sustainable and supported by scientists. Teachers must be exposed to the process of scientific inquiry, not just the end products of research that have taken years to trickle down into textbooks. An inordinate focus on science content only reinforces the inadequacy many teachers already feel about their own science content knowledge. According to Bowers (1996), the lack of knowledge of science content as the primary reason that teachers do not teacher science well is a myth. When the focus is switched from content to process, the hesitation of teachers to teach science is greatly diminished.

The scientific community has a responsibility to provide resources to teachers and assist schools with seeking outside funding for science education (Heinmand 1995). Scientists should provide mentoring and coaching to enhance the capabilities of schools to be the interface between science and society. JC NERR education programs strive to provide educators with access to real-time scientific data and resources to strengthen inquiry-based learning.

The JC NERR has made a strong effort to provide educators with quality materials developed without bias from industry or environmental advocates. Environmental education has come a long way from the Earth Day celebration of the 1970's. Thirty states now require or strongly encourage environmental lessons as part of the public school curriculum. There is overwhelming support from the school community including parents, students and educators/administrators to utilize environmental education in schools. A 1997 survey for the National Environmental Education and Training Foundation found that 95% of all respondents strongly supported environment based education. However, officials of the North American Association of Environmental Educators concede that mandates for environmental education often do not include guidelines or a budget. Teachers end up relying on free materials from corporations or environmental advocacy groups sometimes laced with environmental or pro industry agendas. The JC NERR has felt a responsibility to provide quality classroom materials as part of its professional development programs.

The JC NERR has made an extra effort in special needs schools in an attempt to fill gaps in current knowledge and improve access to scientific information. Research indicates there is widespread lack of access to science and mathematical resources in urban inner city schools. Tobias (1992) writes, "High ability students at low socioeconomic status high-minority schools may actually have fewer opportunities then low ability students who attend more advantaged schools." Research indicates that young people from disadvantaged areas are often exposed to greater environmental hazards than children from other areas, making the knowledge and critical thinking skills associated with such a program even more valuable. Finally, disadvantaged youth have fewer opportunities and incentives to experience the natural world. The Reserve has collaborated with local government, non-profits, and community organizations to improve urban school access to scientific resources.

Utilized Effective Educational Practices

Scientists and staff of IMCS spent a number of years researching and identifying model education programs that would represent the educational goals and objectives of the Reserve program. Years of research and association with our partners principally including the Lawrence Hall of Science at the University of California at Berkeley and Stevens Institute of Technology in Hoboken, NJ has allowed IMCS to develop pedagogical approaches based on best practices.

JC NERR education programs strive to be learner-centered and have a constructivist paradigm that adapts to the needs and interests of the students. Teachers become facilitators, enabling students to use active techniques, such as experimentation and real-world problem solving to create knowledge. The students' newly

created knowledge is based on asking questions, exploring, and assessing what they already know (Brooks 1993, 1999). Constructivism transforms the student from a passive receiver of knowledge to active participant in the learning process. Students are stimulated and engaged in learning because learning activities are grounded in an authentic, real-world context. Students use their natural curiosity of the marine environment as an intrinsic motivator to improve their thinking and communication skills.

The JC NERR develops classroom materials in partnership with scientists and educators to promote the development of problem-solving skills, the conduct of systematic observations, the interpretation and analysis of information, the drawing of conclusions, and the communication of results. Inquiry-based learning using hands-on and minds-on activities produce high quality learning experiences in both the classroom and field. *In Science for All Americans* (AAAS, 1990), a number of effective science teaching principles are presented which illustrate that teaching should be consistent with the nature of scientific inquiry. Understanding the process by which scientific knowledge is acquired is just as important as what is learned. Educators should be provided with access to current scientific information and technology and equipped to present science in an active learning environment where the learning process becomes more important than the memorization of facts and figures.

The JC NERR recognizes the need for innovative materials that provide teachers with the knowledge and skills they need to help their students work toward science literacy. Bowers (1996) states there is a perceived need for inquiry-based materials for the 6-12 grade levels. Over the past several years, numerous companies have begun marketing excellent early science (K-5) curriculum. However, beyond the elementary school level there is no outstanding, readily available inquiry-based curriculum (AAAS Report: Heavy Books Light on Learning 2000). Many middle and high school textbooks cover too many topics and do not develop them well. Current higher-grade level materials are lecture based with cookbook laboratory exercises that do not help students relate what they are doing in class to underlying ideas. IMCS has responded to a perceived need of inquiry-based activities that utilize real-time data in the classroom and focus on current oceanographic research.

The Reserve has developed a number of educational programs that take advantage of the benefits of collaborative learning. Collaborative learning may be defined as a method of teaching and learning in which students team together to explore a significant question or create a meaningful project (Johnson 1991: Weber 1999). Students become actively involved in content, take ownership of their own learning, and learn to resolve group conflicts and improve teamwork skills by working on cooperative projects. The Reserve has found that a particularly compelling use of cooperative learning involves the use of the Internet. With the Internet, collaboration can occur regardless of barriers to distance or time. The Internet also provides access to real-time scientific data and collaborative opportunities with scientists and other classroom experts.

Materials either adopted or developed by the JC NERR encourage educators to create opportunities for authentic learning based on students' interests, needs, and talents. Educators are encouraged to define their students' intelligence more broadly by subscribing to the Triarchic Theory of Intelligence, developed by Professor Robert Sternburg of Harvard (1985). This theory states that all humans have multiple intelligences, including analytical, practical, and creative intelligence. Using this theory, educators can use visual arts, music, and dance as well as science and math as valuable tools to improve students' understanding of the real world.

Use the environment as an integrating context across disciplines and subject matter

Peer reviewed research has shown that the interdisciplinary integration of subject matter can serve to break down traditional boundaries between disciplines. Over the past several years the interest in curriculum integration has intensified. Proponents point out that knowledge in all areas of study is growing exponentially. In the sciences, for example, research and practice has created a remarkable body of knowledge. Each area of the curriculum has the blessing and burden of growth (Jacobs 1989).

By using the Environment as an Integrating Context (EIC) for learning, schools can improve their ability to provide interdisciplinary, collaborative, student-centered, hands-on, and engaging learning environments for their students (Lieberman and Hoody 1998). EIC-based learning is more than just increasing environmental awareness; EIC uses the school's surrounding area and community to allow students to construct their own learning, guided by teachers using proven educational practices.

A study completed by the State Education and Environment Roundtable indicates 92 % of students in EIC programs outperform their peers in traditional programs (Lieberman and Hoody 1998). Evaluation results from administrators and educators involved in ocean

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education programs indicate that children are naturally fascinated with the ocean and this content focus in the classroom can improve students' acquisition of basic skills including language arts and math.

Use evaluation strategies as part of a continuous effort to revise and improve the science program

The JC NERR has assessed and evaluated its program teaching strategies to determine if they support the intended learning goals and objectives of the Reserve program. This type of inward reflection provides useful data that allows the JC NERR to develop more effective education programs and resources. JC NERR education staff has gathered information and data using surveys and focus groups on the educator's knowledge and attitudes regarding marine science education. This *Front End* evaluation, or needs assessment, allows for the collection of information critical to planning an effective education program.

The Reserve also engages in *Formative* evaluations, which involve a continuous stream of reflection and feedback, allowing the educator and student to make mid course corrections in their work as it is ongoing. The more traditional *Summative* evaluations focus on the collection of feedback after instruction has been completed (Parsons 1997; Wiggins 1998).

Involve the community in K-12 science education

Many studies have indicated that parental and community involvement in schools improves student learning. Community members and parents can act as role models and mentors and most importantly serve and an additional layer of support for the classroom educator. The Reserve has been successful in using family science and whole school events such as Ocean Week/Month to generate interest and support from the community for the school's science program.

Use the Internet as a collaborative tool for compelling learning opportunities

It is estimated that in 1850 it took about 50 years to double the world's knowledge base, while today the same feat takes little more than a year. Never before have we had as much information at our disposal as we do now, including the ability to communicate information instantaneously with audiences around the globe. A decade ago found much of the education community heralding computers and the Internet as the next panacea for K-12 learning and education reform efforts. Hopes ran high that increased access to information, made possible by rapidly improving technologies, would result in a new learning paradigm in which students would assume more responsibility for their own learning. Students would use technology to develop the skills to locate, organize, analyze, and convey information themselves, rather than absorbing an established body of knowledge. Yet today, with technology faster and more available than ever, the effectiveness of this tool in the classroom remains a source of great debate.

Americans are investing billions of dollars at local, state, and national levels to bring computer technologies to our schools. The education community generally agrees that technology can only be effective in the educational arena if a "human infrastructure" exists to guide its application. Technology serves as an educational tool, and its usefulness is determined by the quality of the curriculum content and instructional strategy it helps to employ. In light of this, educational issues such as curriculum reform, professional development, assessment, and equity must be addressed as they relate to technology.

Efforts have been made by a number of organizations to use technology to bring ocean sciences education into the K-12 classroom. The innate human fascination with the ocean, coupled with the interdisciplinary nature of the ocean sciences and accessibility of ocean data, creates an excellent opportunity for incorporating technology into the learning experience. The Internet provides the ability to greatly increase (1) communication and collaboration among students and teacher, (2) the range of resources available to students, and (3) opportunities for students and educators to present their ideas and opinions.

Model Programs in K-12 Marine Education

There are many ocean science education programs worthy of mention, in a review of *Best Practices* such as this. The National Marine Educators Association (NMEA), which is affiliated with the National Science Teachers Association and the American Association for the Advancement of Science, provides a valuable focus for marine and aquatic studies world-wide. There are a number of well-planned efforts at coordinating Ocean Science education activities. For example, the Bridge (http://www.vims.edu/bridge/) catalogs a selection of the best online resources for marine science education. Developed by Dr. Lee Larkin and Vicki Clarke at the Virginia Institute of Marine Science (VIMS), this on-line resource catalogs marine science resources available to K-12 teachers.

The "Consortium for Oceanographic Activities for Students and Teachers," or COAST, (http://coastnopp.org/index.html) is a working collaboration, led by

Dr. Sharon Walker, designed to effectively deliver oceanographic and coastal process education to pre- and in-service teachers from kindergarten through the twelfth grade (K-12). Project Oceanography (http://www.marine.usf.edu/pjocean/index.html), created by Dr. Paula Coble from the University of South Florida, is a live cable television program designed for middle school science students. Each week during the school year, students learn about a variety of ocean science topics taught by real scientists and delivered to the classroom via cable TV. The JC NERR is involved in a nationally coordinated program called Marine Activities Resources & Education (MARE) that focuses on whole school engagement in interdisciplinary hands-on lessons.

Marine Activities Resources & Education (MARE): A Model Program

MARE, which was developed by the Lawrence Hall of Science at the University of California at Berkeley, is an interdisciplinary, whole school program that engages teachers, students, parents, administrators, and the community to transform elementary and middle schools into dynamic laboratories for the study of the ocean. The program, created in 1991, has been successfully implemented at over 250 inland and coastal schools in five states including California, Texas, Colorado, Michigan, and Oregon. MARE is especially designed to improve science instruction for all students while promoting equity, language acquisition, environmental awareness, and academic excellence. MARE was selected as one of the 50 most Promising Science and Math Programs in the U.S. and as a Best Practice by ten Regional Eisenhower consortia funded by the U.S. Department of Education Office of Educational Research and Improvement.

The MARE curriculum associates each grade level with a different marine habitat. Crossing disciplines, and linking subject areas, this curriculum helps students understand the overarching principles of science. The curriculum is aligned with and supports Project 2061 Benchmarks for Science Literacy and the NRC National Science Standards for Science Education. Grades K-3 study shoreline habitats that are more familiar to younger students (K-1: rocky seashore; grade 2: sandy beaches; and grade 3: wetlands). Grades 4-5 study offshore habitats that are generally less familiar and represent more abstract processes (grade 4: kelp forest, grade 5: open ocean). Middle schools study even more remote habitats that are of global ecological significance (grade 6: islands, grade 7: coral reefs, and grade 8: polar seas). At each grade, the MARE habitat curriculum provides a minimum of 10 weeks of inquiry-based, hands-on activities, covering an integrated treatment of earth & physical science (substrates, properties of water, currents, tides, weather, seasonality, etc.), environmental issues (human dependence on the ocean, resource use, pollution, habitat loss, etc), mathematics, language, arts/literature, social studies, art, music, and drama.

Individual teachers at MARE schools use the thematic curriculum at their own pace throughout the year as a vehicle for coordinating and weaving together all of their science instruction. Each school chooses one portion of the year, however, when the whole school can work together intensively in an immersion style event, called Ocean Week (Ocean Month in subsequent years). Ocean Week transforms an entire school into a laboratory for the discovery and exploration of the ocean. During Ocean Week, teachers devote 100 % of their instructional time to integrated ocean studies. Students take field trips and work together on special class, cross grade and whole school projects. Expert guest speakers visit the school. Parents flood in to observe the excitement and end up helping in new and unprecedented ways. Janitors, school secretaries, art teachers, and cafeteria crew all suddenly become science teachers because of their experiences and special perspectives. Ocean Week can be characterized as a positive disruption at schools, an event that overcomes the normal constraints faced by teachers.

Over the last several years, the New Jersey MARE program has trained hundreds of elementary school teachers from 27 schools (9 school districts). IMCS has worked with a range of urban, suburban, and rural schools from across the state. Over 10,000 students will be involved in the MARE program this year. The success of the program appears to be a professional development tining model that is entertaining, educational, and practical. Each summer, a team of educators, scientists, and peer trainers conduct a weeklong Summer Institute where educators are treated to scientific lectures, classroom demonstrations, and field trips.

Upon evaluating MARE with focus groups, surveys, and other evaluation tools, the participants attribute the success of the program to the "*peer teaching*" format, the help and guidance of IMCS staff during the program and throughout the school year, and the high quality classroom materials provided. Summer Institute participants cited benefits such as addition of exceptional lesson plans, increased knowledge of marine and coastal sciences, confidence in the classroom (answering questions, choosing experiments, etc.), and the ability to share knowledge and ideas with other teachers. Other benefits included access to current information on the environment and new scientific trends, and increased awareness of potential careers for their stu-

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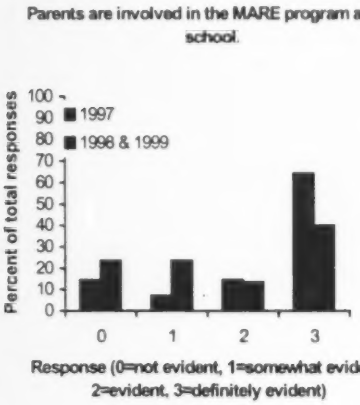
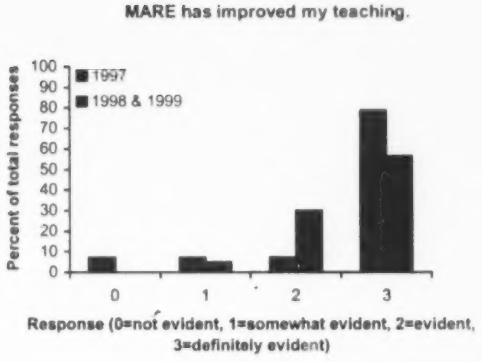
dents. Participants also reported that the MARE program increased parent involvement in the science program.

MARE staffs at IMCS and the Lawrence Hall of Science feel strongly that this program is a successful example of how scientists and educators can work together to spark interest and meaningful learning in the classroom. The MARE program short circuits the arduous rote memorization of traditional test books and allows teachers to experience first hand the scientific and cultural resources of New Jersey and translate that experience to the classroom. Through MARE, these experiences are made available to New Jersey students, some of whom will become tomorrow's scientists and engineers, and all of whom will be challenged to make informed decisions on future environmental issues.



Participants report that the MARE program encourages parents to be involved in Ocean Week. Community members are invited to the school to assist with lessons, read ocean-related literature to students, and participate in field trips.

> "Parents report kids have an increased interest in science as a result of Ocean Week."
>
> 4th Grade Teacher
> Little Brook Elementary School
> Princeton, NJ



The Coastal Ocean Observation Laboratory (COOL ROOM)

IMCS has developed a series of Internet-based, instructional modules that link classrooms with active research investigations at the Coastal Ocean Observation Laboratory (COOL) and the Long-term Ecosystem Observatory (LEO). Scientists have set up several data collection systems that monitor the coastal waters yearround to help them learn and understand more about the underwater coastal zone of New Jersey. The first of these systems was the Long-term Ecosystem Observatory, or LEO. Located just 10 km offshore in 15 meters of water, LEO consists of two underwater nodes linked via an electro-optic cable to the Rutgers University Marine Field Station in Tuckerton, NJ. LEO has the ability to instantaneously deliver data such as information on water temperature, salinity, visibility, wave height, wave period, chlorophyll (phytoplankton) content, and current speeds and directions from the ocean depths to the classroom via the Internet. These measurements, taken in the water, are complemented by satellite data received at IMCS, which tells scientists about sea surface temperature, water quality and phytoplankton content over a 40 degree latitude x 50 degree Longitude area.

Scientific data is posted on an Internet website (www.thecoolroom.org) for use by scientists, resource users, educators, and students. The COOLroom is the first of its kind in the world and is expected to be one in a series of nodes created along the East Coast of the United States. From the LEO data, scientists will be able to make physical and biological forecasts. The US Navy is using the information they learn from LEO to improve their ability to predict what type of ocean weather S.E.A.L.'s may encounter during military operations. CODAR, or Coastal Ocean Radar, can be

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erations. CODAR, or Coastal Ocean Radar, can be used to predict surface ocean current direction, which is useful to the U.S. Coast Guard in search and rescue efforts. Optical sensors may allow scientists to predict red tides, which are the sudden bloom of a kind of microscopic organism that can kill marine creatures and injure humans.

Instructional modules prepared for middle and high school (6-12 grade) level students focus on development of critical thinking and analytical skills and utilize student fascination with the ocean. In collaboration with Stevens Institute of Technology and with the support of the National Ocean Partnership Program (NOPP), the modules were developed with input from scientists, technicians, school administrators, and educators. Each module was written in support of the National Science Education Standards, addressing fundamental abilities in scientific inquiry, life sciences, population and ecosystems, and earth and space sciences. Internet topics range from the technology associated with an undersea observatory, effects of wind on water motion, relationship between weather and ocean circulation, physical characteristics of the Gulf Stream that can be measured and interpreted with remote sensing imagery, and oceanographic processes such as upwelling.

The instructional modules are journal-based and require analytical skills to synthesize and display time-series information. Each module permits students to access real-time data at LEO and explore data applications. Students participate in the same predictive process used by IMCS oceanographers. One of the more popular modules encourages students to predict a "good beach day" by using LEO data. Students learn about coastal upwelling, the winds which blow from the southwest along the New Jersey coast causing NJ coastal water to be cold and turbid on the warmest days of the year.

Best Practices: Summary

Programs like MARE, Project Oceanography, and COAST are bringing positive change to their learning environments through well-planned professional development programs, and the development of exceptional classroom resources. However, the Ocean Sciences lack a coordinated national effort in education. This problem is soon to be remedied through the establishment of a Center for Ocean Sciences Education Excellence (COSEE). This effort will be led by the National Science Foundation and will establish a nationally coordinated program for Ocean Science education in both formal and informal education sectors (McManus et al. May 2000).

Parameters for Best Practices in Technical Training for Coastal Decision-Makers

One of the major thrusts of the JC NERR program is to develop and provide information for better resource management. Community leaders, resource users, planners, regulators and resource managers make decisions each day that affect land use and the use of coastal resources. Difficult decisions are routinely made with insufficient information. In 1988, the Rookery Bay National Estuarine Research Reserve in Naples, Florida implemented its first coastal decision-maker workshop, targeting environmental professionals. The Rookery Bay workshop became the model for the Reserve System's Coastal Decision-Maker Workshop series. These workshops now serve as the backbone of a suite of technical training opportunities offered through the Coastal Training Institute initiative currently being developed in all 25 Reserves in the NERR system.

JC NERR staff conducts a variety of technical workshops on regional coastal management issues directed toward local government officials and other decision-makers. These workshops and programs foster a community-based approach to environmental stewardship and informed decision-making by marshaling the best available scientific information and best management practices for application in land use management decisions. The Reserve has utilized the following criteria and best practices in designing and conducting coastal decision-maker programs.

Understand the Audience Need

Community leaders including planners, resource managers, and regulators are very busy, and almost always need information quickly to meet the demands of their jobs. Often these positions have high turnover. It is important to assess the informational needs of the audience and understand the attitudes and professional culture. Assessing the audience's informational needs ensures efficient and targeted training.

Design and Implement Effective Training Workshops

The NERRS program is working to develop an effective model for coastal decision-maker workshops (Allen *per communication*). Essential elements of an effective workshop include 1) clearly defined educational goals and objectives, 2) materials that accommodate different learning styles, 3) the use of field trips and/or small/large group discussion to enhance learning, 4) selection of dynamic and knowledgeable speakers, and 5) good logistical planning (refreshments, facilities, etc.). NERRS educators also report that pro-

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viding incentives to participants in the form of continuing education credits or certificates can often increase participation in the workshop. Participants value and appreciate time built into the agenda for professional networking.

A good facilitator is invaluable in assuring that the workshop stays on the published schedule and contentious issues/discussions are handled efficiently and equitably. The NERRS program also has noted the importance of developing appropriate hand-outs and follow up materials that are readily available. This may include language translations as the audience need is defined.

Develop technical tools to improve data delivery to coastal decision-makers

A major goal of the NERR is to offer sustainable technical support coupled with professional training to the coastal management community. The Reserves are working to develop Geographic Information Systems (GIS) visual resources (maps) that will allow coastal decision-makers to visualize scientific data including water quality, land use patterns, and the location of sensitive habitats in Reserve communities. These tools will promote the partnerships necessary to exact long-term improvements in land use decisions.

Best Practices in Technical Training for Coastal Decision Makers

The Coastal Decision-Maker Workshops, which are offered in all 25 National Estuarine Research Reserves in the U.S., teach coastal decision-makers about applied and theoretical coastal management issues, including improvements to water quality, habitat restoration and mapping technologies. The close connection between research activities, ecological monitoring and education in the Reserve System ensures the dissemination of timely information to workshop participants. The location of most reserve facilities (adjacent to their respective estuaries) provides participants both classroom and hands-on field experience. For example, Old Woman Creek National Estuarine Research Reserve is actively involved with local landowners and resource managers in precision farming and stream bank stabilization projects to reduce non-point source pollution. In Florida, Rookery Bay National Estuarine Research Reserve staff received support from the Florida Coastal Management Program to develop a watershed restoration and management plan for local, state and federal agencies. In North Carolina, Reserve staff is pioneering new streaming video technology to deliver technical information via the Internet to the desktops of coastal managers. This media allows scientists, coastal managers, and educators to collaborate, brainstorm, and learn through the convenience of their desktop.

The JC NERR initiated its Coastal Decision-Maker Workshop series in the spring of 1999 and has provided a broad range of technical training programs to a local coastal management community. A series of workshops focusing on water supply issues drew broad participation from local, county, and state officials. The water supply workshop presented information on a variety of strategies and funding mechanisms that local communities can use for water supply planning, conservation, and awareness. A traveling seminar, entitled "Building Livable Communities: Land Use Strategies," has been designed to provide training and information to elected and appointed local government officials. The counties that are within the JC NERR are among the fastest growing counties in New Jersey, the most densely populated state in the nation. This program focuses on growth management issues, such as strategies to protect water quality, reduce infrastructure costs, conserve open space, and retain community character.

Other technical training programs include a habitat restoration workshop series that focuses on key coastal and marine habitats within the region. Restoration is defined as applying technology to return an area from its disturbed or altered condition to its previous structure and function. This workshop series was designed to facilitate the transfer of current research to the coastal management community. As a result of these programs, coastal interest groups, management entities, and technical practitioners should be better equipped to successfully restore degraded coastal and marine habitats. JC NERR staff also delivered workshops on "smart growth," and most recently, convened a scientific and management workshop on the impacts of motorized boats on shallow water systems. The JC NERR has worked closely with the New Jersey Department of Environmental Planning, Office of Coastal Management to design and deliver Coastal Decision-Maker Workshops.

Conclusion

The Ocean Science community is stepping forward with new integrative concepts for teaching science. The JC NERR successfully capitalizes on human interest and fascination with the ocean by using the marine environment as an entry point to develop interest and capability in understanding science. With the selection of model science programs, and the development of collaborative school projects and Internet connections, the JC NERR strives to make science education more exciting and relevant to current environmental policy issues. Model programs such as MARE and the

Coastal Decision-Maker Workshop Program promote the education of the public about the ocean and its influence on the quality of their lives and the prosperity of the nation. Future efforts such as NSF's COSEE program will serve to coordinate both informal and formal Ocean Science education efforts nationally.

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